tions (and they certainly are of the highest importance when we try to consider all the features of time and duration, intensity, and direction and the attending noises) still, owing to the fact that observers are generally taken unawares, the Editor must urge those persons, and especially those institutions that can afford to maintain a Weather Bureau seismograph, to contribute thus greatly to our knowledge of this subject. In the annual report of the Chief Signal Officer for 1875, pages 374-377, the Editor submitted a few suggestions as to the observation of earthquakes. Among the apparatus for recording direction the following suggestion may be worth considering: The linear extent of the horizontal movement of the earth may be computed from the movements of several heavy balls of different diameters and moments of inertia rolling or sliding on a perfectly horizontal plane. The plane should be strewn with a fine powder that will serve to mark the path of each ball. The balls should be covered with a very thin layer of some lubricant, such as tallow, to which the powder will stick if the ball should roll. The plane should have a rim and a glass cover to exclude dust and wind. Every detail of the motion of the balls will thus be recorded on their own surfaces and that of the plane. The horizontality of the plane must be determined after the earthquake shock as well as before. The balls must be as truly spherical and homogenous as possible, and, in order to secure different sizes and densities one might, for economy's sake, use the steel balls of the bicycle axles, the best of agate marbles, billiard balls of ivory and the Japanese spheres of quartz crystal. From the recorded movements of these balls one may deduce the direction and force with which they were projected from their original position of rest by the earthquake shock, but the computation, of course, involves a knowledge of dynamics.]

FROSTS IN SOUTHERN CALIFORNIA—THEIR PREDICTION AND PREVENTION.

The following article from the Los Angeles Express of January 4, 1896, presents the valuable results of much experience in that region, and may apply, with slight modifications, to some other portions of the country:

One of the most reliable horticulturists of this section, James Boyd, of Riverside, has laid down some rules bearing on this subject, in the Press, that are interesting, and their correctness is vouched for by years of experience and observation. He states that, as a matter of fact, the thermometer has seldom been known to fall between sunset and sunrise more than 10° in a cold wave, or, say, to make sure, from 7 to 8 o'clock at night to the same hour next morning. For instance, if the thermometer is above 40° at 8 o'clock at night, it need not be expected to fall below 30° before the next sunrise, although sunrise sometimes witnesses a fall of a degree or two for a few minutes, which usually does but little harm.

Again, if the wind blows all night, no matter how cold it feels, it will not freeze to hurt anything in the orchard; but if the north wind blows cold all day and dies down about sundown, with snow on the San Bernardino Mountains, it is well to prepare for the worst. But, again, if the barometer is low there will not come a destructive freeze. All of our injurious frosts have come with an exceedingly high barometer, and, no matter how much it may threaten, the cold is not likely to be excessive. The thermometer may stand for hours below the freezing point without freezing the fruit. If, on cutting the fruit, the juice flows freely it is not damaged. It must not be forgotten that it takes a much greater degree of frost to freeze a mixture of salt and water or sugar and water than of pure water, which fact is what saves the fruit; and green fruit is much more easily damaged than that which is ripe; a fact that is demonstrated every season in our vineyards, where immature grapes will be frozen while ripe fruit will be untouched.

There is one other point that may be laid down as a certainty, and that is, that the thinnest film of haze overcasting the sky will immediately raise the temperature several degrees. It is better not to run water, except when all signs point to a general freeze, for undoubtedly much harm results to the orchard, and also to the fruit, from having the ground saturated for days, or even weeks, at a time, for rain usually follows any cold spell in a few days, and the constant wetting of the soil is very apt to produce puffy fruit later on.

RATE OF ADVANCE OF RIVER FLOODS.

The rate at which river floods advance down the stream must, of course, depend upon the nature of the bed of the stream and the extent to which its banks overflowed. The cross section of the flood of water becomes so large in the lowlands and flats that the forward advance is correspondingly small, and, in fact, every broad piece of overflowed bottom land becomes a pond, temporarily, in which waters may accumulate, and thus diminish the severity of the flood in the lower parts of the stream. Each stream has, therefore, peculiarities of its own and demands a special study. The rates of advance derived from the study of one river can not be applied to another without material multiplication. As, however, detailed studies upon river floods have as yet been made in only a few river valleys, we submit the accompanying report, extracted from the proceedings of the Rochester Academy of Science, as illustrating the class of work that might profitably be repeated by engineers, for the smaller rivers at least, throughout the country. When we know at what rate the small rivers feed the larger ones we shall be better able to study the floods in the latter.

Mr. J. Y. McClintock, surveyor for the city of Rochester, having returned from an examination of the Genesee River in May, 1894, gave an address, of which the following is a summary:

We have lately seen in the Genesee Valley the third greatest flood that has occurred for thirty or forty years. Studies have been made to determine at what rate of speed the height of the flood traveled from Mount Morris to Rochester, and as this flood ran great enough to cover the broad flats it gave a good example. I found that the flood was at its height as follows: Mount Morris, May 21, 3 a. m.; Geneseo, May 21, 12 m.; York, May 22, 9 a. m.; Avon, May 23, 6 a. m.; Rochester, May 23, 2 p. m.

The distances down the general course of the valley are as follows: Mount Morris to Geneseo, 5¼ miles; Geneseo to York, 3 miles; York to Avon, 5¼ miles; Avon to Rochester, 18 miles.

This shows that the flood starting from Mount Morris moved at the following speeds: To Geneseo, 0.6 mile per hour; from there to York, 0.14 mile per hour; from there to Avon, 0.21 mile per hour; and from there to Rochester, Court Street dam, 2.25 miles per hour. The total time from Mount Morris to Rochester, 59 hours.

Apparently the velocity increases gradually, although not regularly, depending upon the width of the valley, which is very much narrower below Avon than above, and affords less storage capacity.

From our observations at Rochester we had come to the conclusion that the flow of water during this flood was nearly one-third less than the flow of 1865, when so much damage was done. I was able to verify this conclusion by interviews with old residents at various points along the river. At York the high water of 1865 was about three feet above that of 1894. At Avon it was somewhat over two feet above.

One other important point was as to whether the great flats would furnish storage room for the flood below the surface of its ground to any such extent as is usually assumed. This I was able to learn by ocular demonstration.

The river banks proper are generally quite steep, of clayey soil, from 8 to 12 feet high, and as the level of the river had fallen from 12 to 15 feet within a few days, the ground has not had time to dry out, but was exuding water from its whole surface. This showed that the flats act as a great storage. The importance of this will be shown by Mr. Rafter in his forthcoming report on the proposed storage dam. He will call attention to the fact that the 60 to 80 square miles of flats when soaked with water will hold far more than the great reservoir to be made.

STORM WAVES ON THE GREAT LAKES AND THE OCEAN.

The waves that occur on a body of water are of several kinds and origins. We speak of short waves and long waves when we have in mind those that can be seen in their whole extent from any ordinary point of view. The lengths of such waves, from crest to crest, vary from a few yards to a mile. We speak of a ground swell, or a long swell, when the rise and fall of the water is but a few feet, and takes place so gently that we scarcely see it as a wave on the surface of the water, but either feel it by the motion of the vessel or recognize it by the character of the surf. The small waves due to light winds, or to the interference of two opposing currents of water, are generally known as ripples or rips; there is, however, a still smaller wave known as the capillary ripple, which does not concern us here. Some forms of ocean swell are due to distant storms whose violent waves have, in the course of 1,000 miles, subsided into long and gentle swells. Other forms of ocean swell are due to earthquakes or volcanic eruptions that produce a great commotion in some central locality whence the wave spreads in all directions. The longest and gentlest wave is the primary tidal wave which is the source of the ordinary tides in harbors and gulfs; this primary wave has a central height of only a few feet in mid-ocean, and would have a length from crest to crest of half the circumference of the earth, were it not for the interference of the continents. The tidal wave advances westward at the rate of 15° of longitude per hour. All waves, including the tide, become shorter and turn into breakers when they reach shallow water. All waves are reflected from the shore line as a wave of sound would be from a stone wall. By combining together several small waves there may result a special great wave. When a broad wave meets and passes beyond an obstacle, the deflected waves interfere with each other in the rear of the obstacle.

The bottom of a lake may be so shaped and so adjusted to the water it contains that the distance from one side of the lake may be exactly one-half of the wave that would naturally be formed in water of that depth, so that the water in the lake can be set into such a wave motion that as it goes down on one side it rises on the other and vice versa. In such cases observers on opposite sides of the lake simultaneously record high water and low water, respectively. This class of waves was first observed in certain lakes of Switzerland, where these waves were known as "seiches," but similar phenomena have been observed in all other parts of the world. This French word indicates a drying-up or retreating of the waters from the shore line, which retreat or apparent drying up may last for several hours, as a maximum, down to several minutes, as a minimum, depending on the dimensions of the lake. If such a phenomenon, or any similar long and slow wave should pass from one end to the other of any one of our large lakes, the amount of rise and fall at either end would depend largely upon the configuration of the sides and shores of the lake.

Another class of waves is due neither to tides, earthquakes, nor winds, but to changes in barometric pressure. We ordinarily measure the pressure of the air by the height of the column of mercury in the barometer, which is supported by the pressure at the open end of the tube, and when we speak of a pressure of 30 inches of mercury we really mean a pressure of about 15 pounds to the square inch, so that each inch of the mercurial column may be considered as representing a half pound of pressure to the square inch. If for mercury we should substitute a column of water it would need to be 34 feet high, as in the water barometer first made by Otto Guericke in 1650 at Magdeburgh. If, therefore, the barometric pressure is one inch higher or greater at one end of a lake than at the other, there is a decided tendency for the water to sink under the heavy pressure and rise under the lighter. Of course, in the free air, such differences of pressure can only exist in connection with a system of winds, and, therefore, the so-called barometric wave is generally of less importance than those due to the direct action of the wind.

It is important for the student to carefully distinguish between these different kinds of waves. Our progress in understanding and explaining the phenomena of nature and our hope of predicting them for man's safety, or utilizing them for man's necessities, all depends upon our correct appreciation of natural causes and our understanding of the laws of nature. As illustrating the confusion of ideas into which the public and well-trained observers may fall, we may quote the rise of water observed at Duluth on Saturday, September 28, when a storm center passed over or near the city. The minimum pressure was 29.68 at 8 a. m., reduced to sea level, while the isobar of 30.15 skirted the eastern shore of the lake. This difference of pressure of about 0.5 inch in a distance of 300 miles was, of course, accompanied by southeast to northeast winds and rain over the greater part of the lake east of Duluth. At the latter city the lake water rose from 2 to 4 feet, according to locality, and this was popularly spoken of as a notable "tidal wave." Now, the fact is, that tides are barely perceptible to close observation in Lake Superior, and tidal waves of 2 feet are impossible. One correspondent explains the wave as due to the difference of barometric pressure; but a half inch of the mercurial barometer corresponds only to a half foot of water, and even this is much more than could possibly have been caused by the barometric conditions over Lake Superior, unless they had remained intact for several days in order to give the water a chance to move into a position of static equilibrium. Even if such static equilibrium should occur, the water would need only to rise a quarter of a foot over the west end of the lake in order to counterbalance the depression of one-fourth of a foot at the east end. But the rise of water observed at Duluth on September 28 was not a case of static or barometric equilibrium, as the reader will see at once, from the fact that the isobars rapidly changed their location and the great difference of pressure soon disappeared. Similar unexpected rises and falls have sometimes been attributed to possible earthquakes, but this hypothesis is probably always out of place in connection with our Great Lakes.

There remains nothing but the wind as a probable cause of the wave at Duluth, and, in fact, the gale that prevailed on Lake Superior, taken in connection with the contour of the shore line, is fully adequate to explain the phenomenon.

The explanations that we have given in previous numbers of the MONTHLY WEATHER REVIEW of the floods caused by hurricanes on our Atlantic and Gulf coasts, apply equally to the high water observed on the Lakes. The wind drives the surface water forward, but when the water reaches the shore and begins to pile up, because it can no longer go forward, it then returns toward the sea by flowing either to the right or to the left, or downward and backward, as an undertow. This forward flow above, and return flow below, is maintained by the wind in such a way as to constitute dynamic equilibrium, but not static equilibrium. If we had to consider only static equilibrium, we should find that a gale can support the pressure due to the weight of only a few inches of water; but in dynamic equilibrium, the steadily blowing wind is perpetually communicating to the onward flowing water a small amount of force, which the latter uses up in overcoming the resistances (such as friction, the so-called viscosity, and the inertia of slowly moving masses). As the undertow flows backward, the forward or surface current has to rise over the underflow, and the work required in order to do this is done by the force that the wind communicates. If the wind blows steadily for a few hours there is established an almost perfect equality between the force communicated by the wind to the surface water and the work done by the advancing surface current and the descending undertow. When the movements of the wind, the upper and the lower currents of water, are all perfectly uniform, this condition is spoken of as steady movement, a stationary condition, or dynamic equilibrium. If the wind should stop suddenly the water would, by its inertia, continue in motion until frictional resistances could use up its slight store of energy, after which it would lie still and the upper surface would be horizontal; this latter is also a stationary condition, but it is static equilibrium; there is no motion, therefore no frictional or other resistances, and therefore, no dynamic manifestations.

The temporary rise and fall of water on our lakes must be principally due to the wind. The disturbances of barometric pressure, the fall of rain, and the tidal action of the sun and moon may contribute a very little to increase or to diminish the influence of the wind, but the latter is the important cause.

These waves should, therefore, not be called "*tidal* waves," but, rather, "storm waves" or "storm floods." A similar misnomer is noticed as to the heavy waves that sometimes unexpectedly occur on the Atlantic and Pacific coasts. Although these waves are generally due to distant earthquakes, yet they are often spoken of as "tidal waves," whereas they should be called "earthquake waves." The "bore," or wall of water, resembling an ordinary breaker, but on an immense scale, which advances up the deltas of many great rivers, and is especially well developed in the Bay of Fundy, is a destructive form of the tidal wave, while the gentle rise and fall of the tide along the coast is the ordinary, quiet form of the tidal wave. Another misnomer occurs in calling the greatest and destructive waves of mid ocean "tidal waves" when they approach like an overpowering wall of water. Thus, the steamer *Progreso*, when off the coast of Lower California, on September 29, encountered a wave that swept her from stem to stern. This is designated as a tidal wave by the daily newspapers, but was, properly speaking, a "storm wave," being a combination of two large waves, or possibly a huge "breaker," but not in any sense tidal.

We note here that the newspaper press reports of "damaging tidal waves" in Duluth Harbor on the 14th and 20th of September, 1895, were quite erroneous. The only important high water at that place was that of the 28th, according to the report of K. W. Brown, local forecast official, Weather Bureau. On Lake Ontario, however, there was observed on September 18, between 6 and 7 a. m., at Charlotte, N. Y., a fall of about one foot, followed by a rise of one foot. At some points on the sloping shore this recession of one foot may have corresponded to thirty feet of the slanting beach, and thus a wild paragraph "water receded thirty feet" was made to startle the country. Ingenious reporters even suggested that this wave in Ontario had come all the way from Duluth through the Lakes and Straits, Ste. Croix River, and Niagara Falls; an impossible performance that makes the suggestion seem ridiculous, although many took it in all seriousness.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (....).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives, for 29 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891–'92, p. 29.

Table V gives, for 28 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891–'92, pp. 26 and 30.

Table VI gives, for 136 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891–'92, p. 19.

Table VII gives the danger points, the highest, lowest, and mean stages of water in the rivers at cities and towns on the principal rivers; also the distance of the station from the river mouth along the river channel.

Table VIII gives the maximum, minimum, and mean readings of the wet-bulb thermometer for 135 stations, as determined by observations of the whirled psychrometer at 8 a. m. and 8 p. m., daily.

The difference between mean local time and seventy-fifth meridian time is also given in the table.

Table IX gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division one may obtain the average resultant direction for that division.

Table X gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table XI gives, for 38 stations, the percentages of hourly sunshine as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table XII gives the records of hourly precipitation as reported by stations equipped with automatic gauges, of which 37 are known as float gauges and 7 as weighing rain and snow gauges.

Table XIII gives the record of excessive precipitation at all stations from which reports are received.

Table XIV gives a record of the heaviest rainfalls for periods of five and ten minutes and one hour, as reported by regular stations of the Weather Bureau furnished with self-registering rain gauges.

Additional information concerning the tables will be found in the January, 1895, REVIEW.